1. Introduction

The National Institute of Standards and Technology (NIST) is responsible for the establishment, maintenance, and dissemination of the U.S. National Scale of Radiance Temperature through its Radiance Temperature Calibration Laboratory (RTCL), which provides temperature measurements above 700 °C. The 1990 NIST Radiance Temperature Scale [1] is based upon the NIST realization of the International Temperature Scale 1990 [2] using principles from blackbody physics. Beginning with the determination of the freezing point of gold (T_{90} = 1064.18 °C), the scale is realized for the range from 700 °C to 4200 °C using radiometric methods. The radiance temperature (also referred to as the brightness or apparent temperature) of a radiator is equivalent to the temperature of a blackbody with the same radiant intensity as that of the radiator's surface at a chosen wavelength.

This document describes the determination of the ratio of the spectral radiance of a tungsten ribbon filament lamp used as a temperature standard to that of a gold fixed-point blackbody at a wavelength of 655.3 nm. A description of the NIST RTCL along with the use and calibration of radiance temperature standards therein is presented in detail. Issues relating to the wavelength calibration, size of source, and linearity of the NIST Photoelectric Pyrometer (PEP) are then discussed. Stability and uncertainties in the scale are considered in detail within the framework of the NIST policy on uncertainty statements described in reference [3].

The NIST disseminates the radiance temperature scale by two methods. The first method involves calibrating ribbon filament lamps as radiance temperature standards in the temperature range from 800 °C to 2300 °C with expanded uncertainties (k = 2)[1] of 0.6 °C at 800 °C, and 1.4 °C at 2300 °C. The second method involves the calibration of customer pyrometers and radiation thermometers. Disappearing filament optical pyrometers are calibrated from 800 °C to 4200 °C with expanded uncertainties (k = 2) of 4 °C at 800 °C, 7 °C at 2300 °C, and 25 °C at 4200 °C. Radiation thermometers are measured from 800 °C to 2700 °C with expanded uncertainties (k = 2) of 2 °C at 800 °C, and 3 °C at 2700 °C.

The radiance temperature calibration services shown in Table 1 are offered through the NIST Calibration Services Program and are listed in the Radiation Thermometry section of the Thermodynamics Quantities Chapter of the NIST Calibration Services Users Guide [4]. A summary of the calibration uncertainties is given in Table 2. This laboratory's quality system is based on the ANSI/NCSL Z540-1-1994 standard and the ISO/IEC Guide 25.

[1] Throughout this paper, all uncertainty values are given as an expanded uncertainty with coverage factor k = 2, thus a two standard deviation estimate. Uncertainties of fundamental units given as a combined standard uncertainty in other documents are restated as an expanded uncertainty (k = 2).

Table 1. Radiance temperature calibration services

Service ID No.	Measurement Description
Calibration reports are issued giving the radiance temperature of the blackbody at 655.3 nm versus the scale reading, output current, or output voltage.	
35010C	Radiance Temperature Standard, Disappearing Filament Optical Pyrometer (800 °C to 2400 °C, 4 to 12 points, 1 range)
35020C	Radiance Temperature Standard, Disappearing Filament Optical Pyrometer (each additional range up to 4200 °C, only available with No. 35010C)
35030C	Additional Interpolated Values
35040C	Radiance Temperature Standard, Disappearing Filament Optical Pyrometer (800 °C to 4200 °C, 3 or fewer points, 1 range)
Calibration reports are issued giving the radiance temperature of the lamp at 655.3 nm versus the lamp current.	
35050C	Radiance Temperature Standard, Ribbon Filament Lamp (800 °C to 2300 °C, 6 to 16 points)
35060C	Radiance Temperature Standard, Ribbon Filament Lamp (800 °C to 2300 °C, 5 or fewer points)
Test reports are issued giving the radiance temperature of the blackbody at 655.3 nm, 900 nm, or 1000 nm versus the indicated reading, output current, or output voltage.	
35070S	Special Tests of Radiation Thermometers

Table 2. Calibration uncertainties

Standard	Temperature Range	Expanded Uncertainty
Ribbon filament lamp	800 °C to 1600 °C	0.7 °C
	1600 °C to 1900 °C	1.0 °C
	1900 °C to 2300 °C	1.5 °C
Leeds & Northrup Model 8000 series	800 °C to 1600 °C	4 °C
	1600 °C to 2100 °C	5 °C
	1900 °C to 2300 °C	7 °C
Disappearing filament optical pyrometer	2400 °C to 2700 °C	8 °C
	2700 °C to 3200 °C	17 °C
	3200 °C to 4200 °C	25 °C
Pyrometer Instrument Model 95	800 °C to 1400 °C	3 °C
	1400 °C to 1800 °C	4 °C
	1800 °C to 2400 °C	5 °C
Disappearing filament optical pyrometer	2400 °C to 2700 °C	8 °C
	2700 °C to 3200 °C	12 °C
Infrared radiation thermometer	800 °C to 2000 °C	2 °C
	2000 °C to 2700 °C	3 °C

The expanded uncertainty (coverage factor $k = 2$) is equivalent to a two standard deviation estimate.